PORTO RICO AGRICULTURAL EXPERIMENT STATION
MAYAGUEZ, P. R.
Under the supervision of the
UNITED STATES DEPARTMENT OF AGRICULTURE

# REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION

# 1928

Issued December, 1929



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## PORTO RICO AGRICULTURAL EXPERIMENT STATION, MAYAGUEZ

[Under the supervision of the Office of Experiment Stations, United States Department of Agriculture]

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## REPORT OF THE DIRECTOR

By D. W. May

The work of the station during the year, as described under the several departments, proceeded unhampered. Investigations in production in the several lines of agriculture included both plant and animal life. There were no changes in personnel, and the position of entomologist continued to remain unfilled. Apparently it becomes increasingly difficult to secure investigators in certain lines of agricultural research.

### IMPROVEMENTS

During the year an addition was made to the east wing of the main building, and the library was moved into it. This now permits the use of three rooms for library purposes and more than doubles the space formerly occupied. A trained librarian was secured to index and classify the library and place it on a modern basis. The usefulness of the library to the personnel of the station and to others has been thus greatly increased.

The tiling system whereby the low grounds of the station are drained was installed 25 years ago. The outlet is through a 4-foot

tunnel emptying into the river. At this point the river bends and cuts into the field. The steady encroachment of the water made it necessary to construct a buttressed mouth to the tunnel and an abutment to shift the current from the field. The material used represented a large outlay of money. The labor was done by the permanent employees of the station during such times as they could be spared from the field.

The station lies along the Yaguez River opposite the city of Mayaguez, and between two asphalted roads which cross the river. The only connecting road between these two roads passes through the station property. The traffic over this road is growing rapidly, and the cost of maintaining it with a gravel surface proved to be increasingly high. Moreover, the dust raised by passing vehicles was detrimental to the work of the station. This road was therefore asphalted and now has a better surface of a more permanent nature than formerly. The Department of the Interior kindly loaned the road roller, vats, and other implements necessary for carrying on the work, which was done by employees of the station.

On the mountain side, 2½ miles distant, where the station has planted a 200-acre plat with forest trees, there is a never-failing spring of clear, pure water. During the year 2½-inch galvanized piping was laid from the spring to the station to convey the water to the station homes, laboratories, stables, and plant houses. The spring has contributed greatly to the success and efficiency of the work of the station and the well-being and health of the personnel. The system is operated at a saving to the station of about $600 per annum.

*Composition of the water.*—A sample of the water when analyzed had a composition as follows:

TABLE 1.—*Composition of spring water on the mountain above Mayaguez*[1]

| Constituents | Per liter | Constituents | Per liter |
|---|---|---|---|
| | *Mgms.* | | *Mgms.* |
| Total solids | 128.00 | Potash ($K_2O$) | (2) |
| Total solids after heating | 92.00 | Nitrogen as ammonia ($NH_3$) | 0.80 |
| Silica ($SiO_2$) | 29.00 | Nitrogen as nitrates ($NO_3$) | (2) |
| Ferric oxide ($Fe_2O_3$) | 1.30 | Chlorine ($Cl_2$) | (2) |
| Lime (CaO) | 28.90 | Sulphates ($SO_3$) | 2.50 |
| Magnesia (MgO) | 7.30 | Carbonates ($CO_2$) | (2) |
| Soda ($Na_2O$) | 3.00 | Bicarbonates ($HCO_3$) | (3) |

[1] Reaction, slightly alkaline to phenolphthalein.
[2] Traces.
[3] Undetermined.

## CATTLE

Cattle were probably brought to the island shortly after its discovery. They were likely shipped in from southern Spain and were good individuals of their type. Their descendants still show characteristics of the cattle of the southwestern provinces of the peninsula. Porto Rico is naturally adapted to cattle raising, and early importations must have thrived so well that further improved blood was not introduced for some time. However, during the nineteenth century some other kinds of improved cattle are reported to have been introduced, and, in fact, indications of such a breed are visible in the cattle of certain districts. Many of the cattle about Guayama,

for example, show undoubted evidence in the ears, dewlap, and shoulder hump of Zebu blood, and the red cattle about Arecibo show evidence in conformation of Shorthorn and Devon blood.

The station has been engaged in importing and breeding cattle in Porto Rico for 25 years. The results of some of the experiments have been of value in present practice and will serve as guides for the future. In 1904 the station brought in three males and one female, all Herefords, in the hope of making crosses for the improvement of the cattle for use as work and beef animals, as is done on the western ranges in the States. These cattle did not thrive as did the native animals. The hot sun and the cattle tick militated against their acclimatization. The station then imported from Texas four Zebu grade bulls the sires of which were purebred Zebus, and the dams showed some Hereford and Shorthorn blood. The animals

FIGURE 1.—Shorthorn bulls at the yoke

were perfectly hardy in Porto Rico and their progeny showed improvement as work animals. The introductions did not improve the beef type, and lessened the desirable quality of milk production. A wildness, quite different from that of the cattle of the island, proved to be their outstanding characteristic.

The station has imported at different times Shorthorn cattle mainly for crossing with native cattle. (Fig. 1.) These introductions greatly improved the stock in various parts of the island, as at Dorado and Guánica. This Shorthorn blood persists and its favorable influence on the herds in Porto Rico adds to its prestige in improving form, hastening maturity, and increasing milk yield.

Probably a larger number of Holsteins than of cattle of any other breed have been imported into Porto Rico. These were brought in because of their high average milk yield. Their acclimatization has been difficult.

Channel Island cattle, the Jerseys and the Guernseys, largely of pure blood, have been introduced. In the main they have done well and have proved to be adapted to the climate. Their short hair affords less protection for the cattle tick. Of the two breeds, the Guernsey is the larger and, therefore, better adapted to work purposes. Again, of all the improved breeds, the Guernsey is nearest to the type of the cattle that may be said to be native to Porto Rico, and it makes the best crosses without undue variations or reversions.

Porto Rico should have only one breed of cattle as have the islands of Jersey and Guernsey. Upon this breed should be built a race of island cattle that will be adapted to the environment and can be bred to the native cattle for improvement in milking qualities and for maintaining ability to work, the two leading requirements in cattle at present. The station recommends the Guernsey as the best general-purpose cattle for island conditions.

The safest way to improve the cattle is by introducing purebred sires of breeds that are best adapted to local needs. The native cattle are strong, vigorous, and of good size. That they have kept their size and quality through several centuries of unscientific breeding is due to the favorable climate and nutritious grasses of Porto Rico. Improvement in crossbreeding is due to the large, robust frame of the cattle and to their climatic adaptability.

The introductions during the past five years included in 1923–24, 620 cattle valued at $71,409; in 1924–25, 1,261 cattle valued at $129,350; in 1925–26, 1,503 cattle valued at $157,622; in 1926–27, 2,184 cattle valued at $212,945; and in 1927–28, 1,258 cattle valued at $123,820. These animals were for breeding purposes and were purebreds or high grades of their respective breeds. The number indicates the acceleration given in late years to the work of improving the cattle of the island.

*Comparison of native with grade and purebred cows.*—That the cattle of Porto Rico may be improved by crossing them with purebreds is shown by the results had with the station herd. The station started a herd with five native cows (fig. 2) and a Guernsey bull. A new purebred bull was purchased as needed to avoid inbreeding. Crossbreeding resulted in the development of half-breds which when bred to purebred bulls produced three-quarter breds. These in their turn produced seven-eighths, and the next generation fifteen-sixteenths breds. The natives gave 2,953 pounds of milk per year, the half-breds, 4,344 pounds, and the three-quarter Guernseys, 4,928 pounds.

In 1923 three purebred Guernsey heifers were added to the herd. By 1928 their female progeny had increased to 15 head, and the males were sold. The last of the grade females were sold in 1928, leaving the station with a purebred registered herd.

*Increasing the milk production.*—The price of milk in Porto Rico is excessively high. This is due to low average yields and the cost of concentrates which are imported. The first difficulty can be overcome by improving the breed, and the second by planting such grain feeds as are adapted to the island. Some root crops, such as the sweetpotato, might be grown also for feeding. Yields of 15 tons of sweetpotatoes per acre have been produced at the station. Mill feeds continue to be imported because no small grains are grown

here. Some corn is grown, but much of it is imported for human consumption and often at less cost than native corn can be had. The station has at different times distributed several tons of seed of kafir, milo maize, and feterita. Though these grow well, especially in regions where the rainfall is deficient, none of them have found sufficient favor with the local farmers to warrant further planting. In addition to the malojillo and guinea grasses, which have been grown for range improvement for many years in Porto Rico, the elephant and Guatemala grasses imported by the station are extensively grown also. Uba cane is satisfactory for sugar production on some lands and yields large amounts of forage in all sections of the island. A successful legume is needed that will furnish protein in the ration

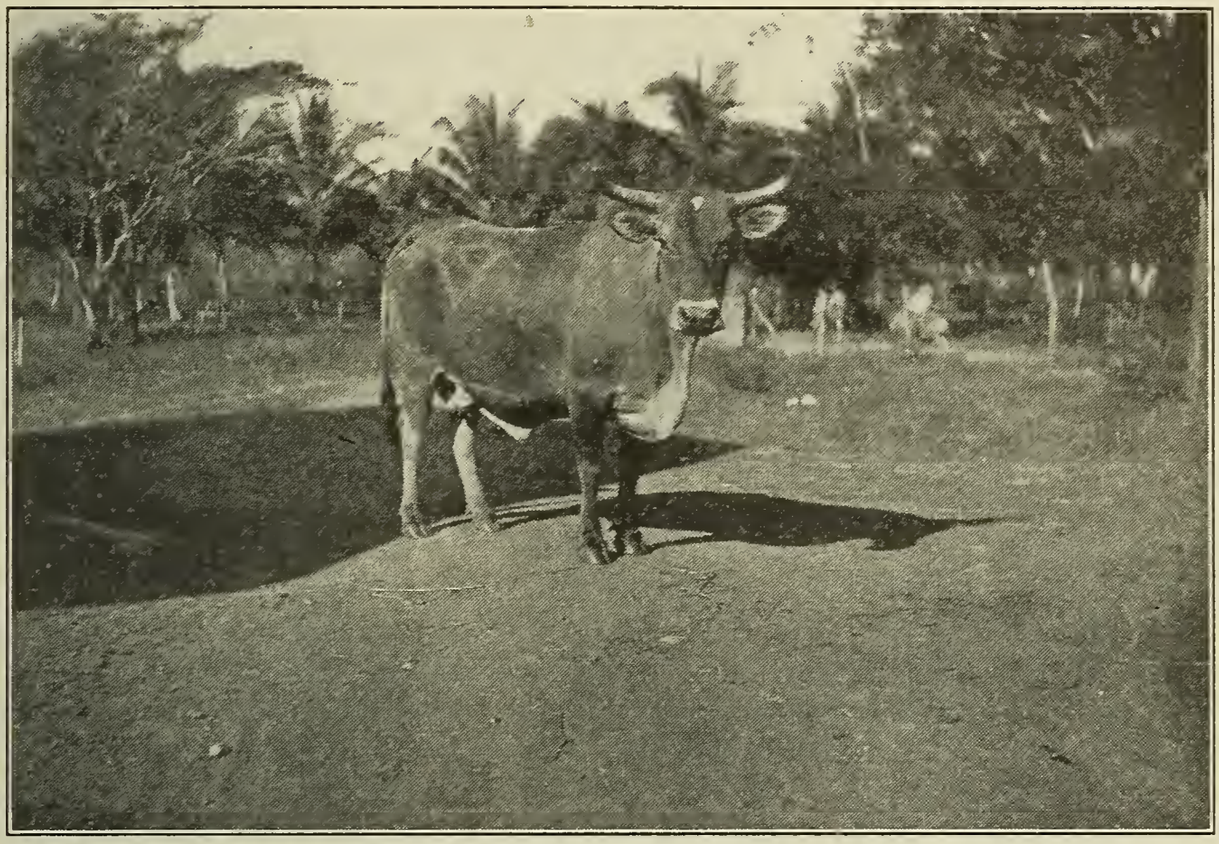

FIGURE 2.—Native cow

and at the same time increase the nitrogen content of the soil. The cowpea or "frijol," as it is locally called, produces well on most soils. The soybean has not become established. Many legumes new to the island have been tested at the station. For general purposes, including soil improvement and use as a feed, the velvetbean succeeds best and over the widest area.

### CLOVERS AND ALLIED PLANTS

Clovers and allied plants afford feed for livestock and also improve the soil by storing therein nitrogen from the air. They are found in any well-grounded system of agriculture in the Temperate Zone. The clovers and allied plants under trial at this station from 5 to 20 years include red clover, mammoth trefoil, Lespedeza, sweetclover, alfalfa, bur, subterranean, crimson, and white clovers. None of these have grown successfully from the first plantings of the seed, or established themselves by reseeding. The seed has been inoculated with the proper bacteria in every instance, and nodules have formed

on the roots. However, growth has been poor, and in most instances the plants have failed to come to maturity.

A clover crop to succeed must overcome the grasses that spring up with it, or must grow on the same soil with them. In the latter instance, the clover should grow at least as high as the grasses to maintain its place in the sun. As the local pasture and forage grasses are rank-growing, clovers maintain themselves with difficulty, especially during the seasons of heavy rainfall. Therefore, under island conditions the successful legume must be cultivated or else make such rank growth as to overcome the grasses by overtopping and smothering them out.

### VELVETBEANS

The velvetbean is native to the Tropics. It was first cultivated as an ornamental. The legume, both vine and seed, makes an excellent feed for livestock, and it has therefore become of great economic importance.

The station has been growing and distributing the velvetbean for 20 years. The first variety tested was known as the Black Bengal. A number of others, differing in color and size of seed and length of vine, have been received for trial. Occasionally a variety will come back with a new name. In the Tropics a quick-maturing variety is not as desirable as in the States. The most forage in the shortest time is the goal. The variety known as Hundred Day will not mature in that length of time here, although it has produced 9 tons of green matter per acre in 100 days. The bunch velvetbean will not hold true to form in the Tropics, but spreads out into vine, showing that its tendency to grow into bush form is not fixed.

On cut-over lands that for years have been unproductive in the station forest plantation, the velvetbean alone, of the many annual legumes tried, gave a large yield. Even the cowpea failed to produce satisfactorily. The velvetbean has also proved to be very valuable in ridding land of nut grass. It is almost impossible to eradicate this pest, once it takes possession of an area, and it may cause the farmer to abandon his farm. Velvetbeans when grown on nut-grass-infested areas at the station completely smothered it out.

Velvetbeans grow well on beach lands where sand largely predominates, and on the clay soils of the interior. They make excellent cover crops on the coconut soils of the coast, crowding out weeds and smothering grasses. They do well in citrus orchards and, while the vine may cover trees to their detriment, it can be easily pruned back with a machete. Velvetbeans may serve a threefold purpose, being used (1) as an ornamental to cover an unsightly object, (2) to add nitrogen to the soil, and (3) to produce forage and grain for feed.

Velvetbean seed is hard to harvest. Harvesting should be done on a rainy day if possible. Prior to planting, the pods need only be broken in two. Local growers should harvest their own seed, since it can not be bought on the island. Seed on hand offers an inducement to the possessor to plant, and planting can be done here during any time of the year. What would be otherwise waste places may be kept growing velvetbeans at a profit.

Velvetbeans when planted on ground for the first time should be inoculated; after that inoculation is not necessary. About 15 pounds

of seed are required per acre. Fertilizing the crop will not pay. Velvetbeans when inoculated take nitrogen from the air, and they make such vigorous growth as to be able to wrest the needed potash and phosphorus from the soil.

As a feed, velvetbeans rank well with cottonseed meal, a highly nitrogenous feed. They contain a high percentage of fat. When the size of the crop permits, the beans can be crushed and the fat extracted for various uses. The residue can be fed to livestock.

At the station no insect has been found attacking the velvetbean.

### UBA CANE FOR FORAGE

Although Uba cane is being supplanted by new seedlings which give a greater tonnage of sugar and are also immune to mosaic disease, it is one of the most valuable of the forage crops tried at the station. (Fig. 3.)

Yields of this cane will run well over 50 tons per acre the first year, and the ratoon crop over 40 tons. In nine months on hill land 33 tons per acre have been obtained.

Uba cane may be fed at any stage of its growth. When it is ripe or nearly so and the stalk has hardened, the cane should be run through a cutter. Cattle ate 80 per cent of fully ripe Uba cane which was cut into 1-inch lengths. Results of experiments indicate that Uba cane and velvetbeans are the greatest producers of the two types of forage—carbohydrate and leguminous—that have been tried at the station. In the latter instance, velvetbeans may be planted with the cane in the stubble remaining after each cutting.

### SURINAM TOAD

The giant toads (*Bufo marinus*) which were introduced into the island five years ago have greatly increased in number and have been shipped to all parts of the island in lots varying from 10 to 1,000. Reports indicate that they are proving to be effective in controlling the changa, or mole cricket, the worst insect pest on the island. An examination of the stomachs of the toad disclosed the presence of other predacious insects also, including ants, grubs, and cockroaches.

### FERTILIZERS

For several years the value of the fertilizers that have been imported into Porto Rico has approximated $3,000,000 annually. They have been used mainly on cane, but also on fruit and tobacco, and their use has been profitable. As is stated elsewhere in this report (p. 16), certain mixtures can be profitably employed in the coffee plantation.

Table 2 shows the value and kind of fertilizers imported into Porto Rico from the United States and from foreign countries during the past five years.

TABLE 2.—*Kind and value of fertilizers imported into Porto Rico during the period 1923–1928* [1]

| Source and period of introduction | Nitrate of soda | | Sulphate of ammonia | | Chloride of potash | | Sulphate of potash | |
|---|---|---|---|---|---|---|---|---|
| United States: | *Tons* | *Value* | *Tons* | *Value* | *Tons* | *Value* | *Tons* | *Value* |
| 1923–24 | 1,095 | $57,420 | | | | | | |
| 1924–25 | 2,185 | 118,618 | | | | | | |
| 1925–26 | | | 9,213 | $511,890 | | | | |
| 1926–27 | 2,809 | 155,596 | 29,375 | 1,615,363 | | | | |
| 1927–28 | 2,527 | 129,102 | 33,858 | 1,502,632 | | | | |
| Foreign countries: | | | | | | | | |
| 1923–24 | 1,988<br>1,087 | 85,399<br>12,374 | (2) | | 1,452<br>4,222 | $52,809<br>186,552 | | |
| 1924–25 | | | 100<br>4,151 | 4,725<br>229,816 | 2,924 | 97,117 | 669<br>966 | $28,946<br>47,700 |
| 1925–26 | 1,544<br>4,007 | 76,375<br>238,279 | | | 2,963 | 95,558 | 2,926<br>1,670 | 122,948<br>70,907 |
| 1926–27 | | | | | 2,365 | 76,660 | 4,113<br>18,767 | 181,447<br>462,777 |
| 1927–28 | | | | | 3,010 | 108,995 | 3,101<br>37,163 | 172,318<br>627,430 |
| Total | 17,242 | 873,163 | 76,697 | 3,864,426 | 16,936 | 617,691 | 69,375 | 1,714,473 |

| Source and period of introduction | Bone phosphate | | Mixed fertilizer | | Total | |
|---|---|---|---|---|---|---|
| United States: | *Tons* | *Value* | *Tons* | *Value* | *Tons* | *Value* |
| 1923–24 | | | 16,675<br>47,873 | $784,690<br>2,184,622 | 65,643 | $3,027,002 |
| 1924–25 | | | 4,861<br>41,612 | 220,051<br>1,878,993 | 48,658 | 2,217,662 |
| 1925–26 | | | 12,586<br>36,079 | 422,373<br>1,390,620 | 57,878 | 2,324,883 |
| 1926–27 | | | 30,002 | 1,127,742 | 62,186 | 2,898,701 |
| 1927–28 | | | 21,271 | 731,042 | 57,656 | 2,362,776 |
| Foreign countries: | | | | | | |
| 1923–24 | 600<br>210 | $21,695<br>4,209 | | | 9,559 | 363,038 |
| 1924–25 | 166<br>681 | 7,290<br>20,667 | | | 9,657 | 436,261 |
| 1925–26 | 506 | 16,933 | | | 13,616 | 621,000 |
| 1926–27 | | | | | 25,245 | 720,884 |
| 1927–28 | | | | | 43,274 | 908,743 |
| Total | 2,163 | 70,794 | 210,959 | 8,740,403 | 393,372 | 15,880,950 |

[1] According to Customs declarations.
[2] Sulphate of ammonia imported from a foreign country is subject to a duty of $5.50 per ton.

During the last fiscal year there was a tendency toward the use of fertilizer of lower value. This is a mistake, especially when one considers that the cost of freight on fertilizer, practically all of which is imported, is $3.40 per ton, and that the cost of bagging and marketing is the same for low-grade goods as for high. True economy here means the use of the least filler possible. Fertilizer for use in the coffee districts in the mountains is subject to another heavy charge for transportation thence on pack animals. Concentrated fertilizers are therefore advisable for the Porto Rican trade.

The station again advises the employment of all such local fertilizing materials as manure, tobacco stems, wood ashes, and vegetable débris. The caves of the island which have been surveyed and mapped by the station are still found to contain many valuable deposits of guano that should be utilized as fertilizer. In some of the caves the annual deposits of bats are considerable, and the owners should regard the possession of them an asset to their farms.

### VEGETABLE GROWING

In a country of equable temperatures and no frost, where the rainfall is abundant or irrigation is possible, conditions apparently should be ideal for growing vegetables throughout the year. In the

FIGURE 3.—Uba cane; fifth ratoon

Tropics, however, the greatest pests and plagues are likely to overtake and destroy the crops. Freezing in winter in the colder regions does something for the soil that can not be done for them in the

Tropics. Again, in the Temperate Zone plantings can be made in time to avoid attack by insect and fungus pests, which are always present in the Tropics.

Other conditions differing from those of the Temperate Zone affect the growing of vegetables in the Tropics. Sweet corn, for example, will rapidly pass through all the processes of growth in Porto Rico, but produce only a dwarf plant with an embryonic ear. This peculiarity is apparently due in part to the shortness of the tropical day, but it represents the difference between success and failure.

The soil is the basis of successful planting, and before it can be used for garden purposes it must be well prepared and fertilized It will then grow most of the vegetables that are produced in the North. The grower must be ready to fight insect and fungus pests from the time of sowing the seed to the time of harvesting the resultant crop, and even then the plants may be overtaken by an unexpected plague.

To grow the white potato successfully the soil should be friable and the plants well fertilized. They will grow quickly and bear tubers, but will not flower. The planted piece will often sprout, grow, and produce, yet remain hard and firm in the ground and not rot. Even the cut surface will be found not to have become discolored or soft. The potato will grow rapidly here, but will not form as large tubers as in the North. The largest yields at the station were made by Irish Cobbler, which produced 164 bushels per acre, and by Red Bliss, which produced 145 bushels per acre. The varieties were planted February 16 and dug May 19.

Of other root crops, the carrot is of easy growth and has no serious insect pests. Turnips are a success, but they should be grown quickly because they soon turn bitter. Young beets are subject to attack by leaf-eating insects. The tops should be dusted with arsenicals. After the plants are well started they will grow rapidly.

Certain parts of Porto Rico are well suited to onion growing. From them profits of $400 per acre have been reported. The greater part of the onions consumed in the island are imported. Porto Rico should supply the home demand and have a balance for export, especially of the large, mild type. They should be grown from seed, and be well fertilized, and intensely cultivated.

Peas are so easily cultivated that they should be found growing in every garden through most of the year. Both the edible and the ornamental kinds grow well, although the soil must be inoculated when they are planted therein for the first time. With later plantings this is not necessary. No insects have been found attacking the foliage at Mayaguez.

Of the salad plants, lettuce, mustard, and parsley grow most easily and are freest from insect attack. Celery also is grown easily, but it lacks the crispness of that grown in the North.

Chard and kohlrabi thrive, but the leaves of the former when young are attacked by beetles. The plants should be dusted with air-slaked lime.

Cauliflower does not head well. Until methods of overcoming this difficulty are determined, its planting is not advised. Cabbages can be grown, but they do not make as large heads as in the North. Commercially, cabbage can be imported more cheaply than it can be grown.

Certain varieties of tomatoes can be grown successfully. The Marglobe is at present the most promising variety. (Fig. 4.) Tomatoes should not be grown two years in succession on the same plat of ground.

FIGURE 4.—Marglobe tomatoes

Occasionally fine melons are grown in a locality which has not previously been planted with them for some time. This encourages attempts to grow them a second time on the same area and results in failure. Insect and fungus pests destroy the crop at the second plant-

ing on the same ground. These are so persistent or so destructive as to continue notwithstanding a reasonable amount of spraying.

### PHEASANTS

In May two lots of eggs of ring-necked pheasants were received from the States and set under hens. From one lot of 60 eggs only 2 were hatched; from the other lot of 50 eggs 32 were hatched. As the result of one of the hens leaving her nest 12 eggs of this lot were lost. Of the 34, 3 of the young died, 4 were lost by accident, and 2 were killed by rats. The rest grew to maturity and proved to be strong, healthy birds. Two pairs have been released on a coffee plantation where the elevation is 2,500 feet. Seven have been released in the neighborhood of Mayaguez. Twelve have been placed with employees of the station for further breeding work in captivity. Results of experiments so far indicate that pheasants may be successfully raised here. Probably the most serious menaces to their increase in the wild state are the rat and the mongoose.

## REPORT OF THE ASSISTANT CHEMIST

By J. O. Carrero

### MANAGEMENT OF CANE SOILS

Results of field experiments on the utilization of nitrogen by cane soils, as reported in 1927, failed to show definite gains in tonnage for plant cane when nitrogen in the form of leaves and trash was added to the crop, whereas a gain was shown by the first ratoon crop. In the first instance the leaves and the trash were buried, and in the second instance they were left on top as a mulch.

Further studies were made to determine (1) the rate of decomposition of the trash, and (2) the effect on the disappearance and reappearance of soil nitrates. The first was accomplished by adding mixed air-dried green and dead cane trash to soils in such proportion as would be applied in the field, conditions as to other fertilizer ingredients being changed to correspond with those used in field trials. This experiment was carried on along two lines, (*a*) to determine the effect on the decomposition of trash of the different treatments applied as shown by the amount of carbon dioxide evolved, and the content of nitrate nitrogen in the soil at the close of the experiment; and (*b*) to permit of making weekly tests for the nitrate-nitrogen content of soils in beakers which had been subjected to similar treatments.

A test was made to determine the difference in rate of decomposition of green and dry trash and a mixture of the two, and the effect of adding lime. Two hundred grams of finely ground air-dried soil was thoroughly mixed with 2 grams of air-dried green and dead cane trash and placed in a 500-cubic centimeter Erlenmeyer flask. Sufficient water was added to maintain the optimum moisture content of the soil. Eight different treatments were used. The quantity of carbon dioxide produced in the flasks during 31 days and the nitrate-nitrogen content of soil samples at the end of the run were determined.

Carbon dioxide production was increased considerably by the addition of the cane trash and further increased by the addition of lime. Green trash decomposed more rapidly than the dry trash or a mixture of the two, regardless of whether the soil was limed or not. Determination was made of the nitrates present in the soil. Unlimed soil showed 31.3 parts per million nitrogen as nitrates, and soil plus lime, 52 parts per million, whereas the rest of the flasks revealed only traces. Thus decomposition had not progressed sufficiently in 31 days to allow nitrification.

A second experiment was carried on to learn the effect on decomposition of (1) adding nitrogen as nitrates, (2) mixing the trash with the soil, and (3) leaving the trash on top as a mulch.

Again the addition of trash was followed by greatly increased carbon-dioxide production showing rapid decomposition of the trash. A more active rate of decomposition followed upon the addition of lime. The addition of nitrogen was not followed by increased carbon-dioxide production, probably because only 30 parts per million nitrogen as nitrates was added. This represents an addition of only 0.2 per cent nitrogen in the amount of trash added. The amount of carbon-dioxide production was considerably increased even when the trash was left on top of the soil as a mulch, but it was slightly below that produced when the trash was mixed with the soil. As to the nitrate-nitrogen content of the soil at the close of the experiment, a decided advantage was shown by the mulched soils over those mixed with trash. Mulched soils showed the presence of considerable nitrate nitrogen even when they were slightly below soils receiving no treatment; on the other hand, soils mixed with trash showed only traces of nitrates even in the pots receiving nitrates in addition.

A third experiment, lasting 11 days, was made, the amounts of nitrates added to the soil in flasks being varied to observe the effect on the amount of carbon dioxide produced. Then the experiment was carried on for 30 days without carbon dioxide determination and for a third period of 12 days with it. Nitrate nitrogen was determined in the air-dried soil samples.

The applications of nitrogen as nitrates were equivalent to 0.5, 1, 1.5, and 2.5 per cent of the dry weight of the trash. Only on the first day of the 11-day period was the difference in the amount of carbon dioxide evolved for the different treatments noticeable. Apparently the increase in nitrate content did not affect the decomposition of the trash. Even after the decomposition had been allowed to proceed for 41 days and another measurement had been made of the amount of carbon dioxide evolved for 12 consecutive days this failed to show a difference in favor of the nitrogen applications. At the end of the test the nitrate-nitrogen content was determined. Even soils receiving no nitrate nitrogen were found to contain varying amounts. Those receiving different amounts of nitrate nitrogen showed increased nitrate content in accordance with the amount received, but they were less than the amounts applied. Lime again seemed to be beneficial since a gain in nitrate was always observed following its use. Apparently the rate of decomposition of cane trash when it was added to a soil progressed sufficiently in two months to permit nitrification of the nitrogen present and especially so when lime was added.

To obtain further information on this point and on the rate of nitrification of the nitrogen of cane trash, an experiment was carried on in beakers. The beakers were allowed to stand for four weeks before the nitrates were determined for the first time. Nitrate nitrogen was then added, and nitrate determinations were made weekly for five weeks.

Mixing cane trash with the soil reduced its nitrate-nitrogen content for four weeks, even when the soil was limed. However, nitrate nitrogen when added in the fifth week was apparently little affected, the soils showing a very small decrease in the amount added. Soils to which the trash was added as mulch were not affected as much as were those having it mixed with them. On the other hand, soils containing a mixture of cowpea leaves and stems soon showed decomposition and the presence of nitrates, the contents surpassing those of soils not receiving any treatment. These results can not be accepted as definite because on two occasions the soils in beakers were found to be almost dry when they should have been kept at a constant moisture content.

To obtain further information on this point a second and more extensive trial was begun, in which 100 grams of soil was placed in beakers. Half the number were limed, and the rest were left unlimed. One set received no treatment, a second received 30 parts per million nitrogen as nitrate, and a third received nitrogen as ammonium sulphate. Two similar lots were prepared, the first lot receiving 1.2 grams of air-dried green and dead cane trash which was mixed with the soil; whereas, in the second the mixture was left on top as a mulch. A third lot received an equal amount of trash and potash (potassium sulphate applied at the rate of 60 pounds $K_2O$ per acre) and phosphoric acid (superphosphate applied at the rate of 60 pounds $P_2O_5$ per acre) with and without the addition of lime and nitrogen as ammonium sulphate. All these were compared with two lots to which 1 gram of air-dried cowpea and velvetbean leaves and stems had been added. These tests had been carried on for nearly four weeks when they were destroyed by a storm that completely wrecked the shed in which the beakers and jars were kept. However, up to the time of the storm the nitrate content of the soil, both untreated and limed, continued to increase, while nitrogen added as ammonium sulphate was completely changed to the nitrate form. Where trash had been mixed with limed or unlimed soil no nitrates were found in the unlimed soils and only bare traces in the limed. Given the same treatment and in addition nitrates or ammonium sulphate, unlimed soils showed bare traces and limed soils from 10 to 15 parts per million. In soils receiving trash as a mulch the nitrates did not disappear even when the trash was applied alone. All soils receiving potash and phosphates, and nitrogen as ammonia, in addition to trash, showed bare traces even when limed, whereas soils with cowpea or velvetbeans showed an increase of 20 to 90 parts per million nitrogen as nitrate in the fourth week of the trial.

Another experiment was begun, but as no cowpea or velvetbean plants were available, air-dried green and dead cane trash was substituted to permit of determining any difference in the rate of decomposition. The experiment was carried on for 14 weeks, and samples were not analyzed until after the first 2 weeks.

Definite gains in nitrate-nitrogen content were made by soils receiving no treatment or only lime, the latter always showing to advantage. Soils to which cane trash but no lime was added showed only traces for 12 weeks and only in the last 2 weeks nitrates amounting to 7 to 8 parts per million, whereas soils receiving lime showed the presence of nitrates in the fifth week. Soils receiving nitrate or ammonia nitrogen showed the presence of nitrate nitrogen very early in the third week. The unlimed soils with ammonium sulphate required 5 weeks for such a showing. The soils varied somewhat, especially in the first 2 weeks, when a high nitrate content was observed. This suddenly dropped between the seventh and tenth weeks. The first was found to be due to the fact that the cane trash had not been attacked and, consequently, decomposition had not taken place. Cane trash does not easily absorb moisture, a fact which delays its decomposition. Again, after several weeks of gains in nitrate-nitrogen formation, the nitrate content dropped suddenly, after which gains in nitrate nitrogen were observed. These losses took place every time water had to be added to restore the amount lost by evaporation. After water was added the nitrate content increased. Soils receiving the trash as mulch showed nitrate nitrogen present during all stages of the experiment. However, they were also subject to a drop in nitrate content whenever water had to be added even though evaporation was considerably less than in the unmulched soils. Those receiving potash and phosphoric acid showed no improvement in the amount of nitrogen nitrified when they were compared with soils receiving trash alone. Soils to which air-dried green trash or air-dried dead trash were added showed considerable difference in rate of decomposition and appearance of nitrates. For green trash unlimed, nitrates appeared in the fifth week and increased gradually, whereas for the limed soils nitrates appeared in the third week, gained gradually, and in the end were twice as high as in the unlimed soils. Those receiving air-dried dead trash unlimed showed only traces throughout, whereas the limed soils showed small amounts beginning with the seventh week. It should be remembered that these experiments were made on air-dried samples of soil, which always show increased nitrification of the soil nitrogen.

Apparently decomposition of cane trash, whether air-dried green or dead trash, or a mixture of the two, progresses rapidly enough in two months' time to permit formation of much-needed nitrate nitrogen in such quantities as are necessary to plants. This action is greatly hastened by adding lime to the soil, and, while decomposition is not apparently hastened by adding nitrogen in its nitrate or ammonia forms, the earlier reappearance of nitrate is thereby obtained. When the trash is applied as a mulch the denitrifying action does not appear to be as vigorous as when the trash and the soil are mixed, presumably because of the contact of the small amount of trash with the soil. Such trash is kept moist and decomposes, whereas the rest is well aerated, dries rather quickly, and is not therefore acted upon; hence, denitrification is reduced. As soil moisture is reduced, soils appear to gain in nitrate content, whereas the addition of water to restore that lost by evaporation reduces

nitrates in samples receiving trash. This action, though not definitely known to occur, may be beneficial, for the reduction of the nitrates to some organic form may prevent loss by leaching.

## REPORT OF THE HORTICULTURIST

By T. B. McClelland

### COFFEE

Results of the station experiments with fertilizer for coffee show in increasing measure the need for fertilizers. Soil conditions must be improved if Arabian coffee is to continue to be grown on typical Porto Rican coffee plantations the original fertility of which was depleted years ago. At various farmers' meetings which were held in the coffee district, the horticulturist gave talks on the benefit to be derived from the use of fertilizers, and exhibited charts showing that production increased when fertilizers were applied to coffee trees. During the past seven years the total production of coffee on the two plats receiving complete fertilizer on the López plantation was 2,692 and 2,712 pounds of coffee (parchment free) per acre, respectively. Fertilizer was applied twice annually throughout this period, each application consisting, on a per acre basis, of 112.5 pounds of ammonium sulphate on one plat and 150 pounds of sodium nitrate on the other, and 150 pounds of superphosphate and 50 pounds of potassium sulphate on each plat. In this same period the two plats which prior to December, 1926, had received nitrogen only, produced at the rate of 1,250 and 1,930 pounds per acre, respectively, and the check plat, at the rate of 1,518 pounds per acre. At present prices of coffee and fertilizer, the value of the increase in crop in this instance was about twice as great as the production cost entailed through the use of complete fertilizer. Since results with other experiments in progress indicate the importance of potash in coffee fertilization, planters are advised to use a considerably higher proportion of potash than was employed in the test here reported.

In the South Field fertilized coffee plats, nitrogen, phosphorous, and potash are applied singly and in combination, the applications of each ranging from very light to very heavy. If all the plats receiving the same kind of fertilizer in different amounts are considered as a unit, and the resultant groups are compared with the unfertilized plats, the production of the NK and NPK groups will be found to have exceeded that of the check in each of the past 11 years. The K group surpassed the check in 10 of 11 years, while the PK group surpassed it in 8 of 11 years. These plats, all of which had received potash, stand in interesting contrast to those to which potash had not been applied. The check outyielded the P and NP groups in 10 of 11 years and the N group every year.

The question of the advisability of topping coffee trees has recently received considerable attention from growers. Here and there in the coffee section, coffee trees have been headed back to test the effect of topping on yield. A manuscript giving the results of an experiment in topping coffee trees at the station over a 12-year period was submitted for publication during the year.[1] The depressing effect on

[1] McClelland, T. B. EFFECT OF TOPPING ON YIELD OF COFFEE IN PORTO RICO. Porto Rico Agr. Expt. Sta. Bul. 32, 8 p., illus. 1928.

production of severe pruning or heading back was less evident in the early years of the test than later. During a 10-year period trees topped at 6 feet and maintained at this height produced only 74 per cent and those topped at 4 feet produced 58 per cent as much as the unpruned check trees.

One of the experimental coffee plantings was heavily invaded by a trunk borer belonging to the genus Xyleutes. Paradichlorobenzene, dissolved in soluble pine-tar oil (1 pound of the former to 1 quart of oil), and diluted with two parts of water, was injected into the tunnels by means of a small hand sprayer having a syringelike nozzle. The percentage of kill could not be determined, because of experimental work in progress with the trees. However, the treatment offers promise since two applications of the paradichlorobenzene were made at a 3-week interval without resultant injury to the trees. The borer has also been found attacking *Gliricidia sepium*, a coffee shade tree.

Planters are evincing a steadily increasing interest in Excelsa coffee. (Fig. 5.) Seed distribution of this variety has been on an extensive scale. The trees in the station plantings on poor, red clay soil under conditions little suited to Arabian coffee have made vigorous growth and produced good crops. Twelve-year-old trees are producing, per tree, about 3 pounds of coffee, with the parchment removed. The trees have averaged for the last five years a little more than 2 pounds per tree annually. The ability of Excelsa to thrive and produce under conditions unfavorable to Arabian coffee makes the variety very promising for planting in many localities, particularly where a less fertile soil, the presence of the leaf miner, a lack of suitable shade, or an insufficiency of the requisite labor during the picking season, constitute major problems.

### PHOTOPERIODISM

Studies of the photoperiodism of various economic plants were continued, and a detailed report covering the main lines of investigation to date was submitted for publication.[2]

The 11 and 13½ hour periods of daily light exposure under which pineapples had produced their first crop were altered to 10 and 15 hours, respectively, for the second or sucker crop. For the latter, the differences in ripening season between groups receiving different exposures were more pronounced than in the first crop. The mean ripening date for the group receiving the normal light exposure was 21 days later, and for the group receiving the 15-hour daily light exposure, 58 days later than for the group receiving the 10-hour exposure. The average fruit produced under the 15-hour daily light exposure weighed 24 per cent more than that produced under the 10-hour daily light exposure, was both longer and broader, and was subtended by a greater number of slips. Only a single fruit of those produced under the normal light exposure attained the weight of the average fruit produced under the 15-hour daily light exposure. Weights taken at the termination of the test showed that the amount of plant growth was correlated to the length of daily light exposure.

[2] McClelland, T. B. STUDIES OF THE PHOTOPERIODISM OF SOME ECONOMIC PLANTS. Jour. Agr. Research 37 : 603–628, illus. 1928.

Such blossoming as had taken place prior to the removal of the plants showed that flowering for the third crop, as for the first and second, was retarded under the lengthened period of illumination.

FIGURE 5.—*Coffea excelsa* at 13 years from seed

Yautias, dasheens, and Penang taros were grown under daily light exposures of 10 and 15 hours. The petiole length and the leaf diameters of the two largest leaves on each plant were measured eight weeks after planting. At that time the dasheens and taros had developed longer and broader leaves and all three had developed longer petioles under the longer exposure.

### YAUTIAS, DASHEENS, AND TAROS

In planting yautias, dasheens, and taros the general practice locally is to remove the soil to a depth of 3 to 5 inches, making for each plant a hole approximately a foot in diameter which is left open. The hole gradually fills by subsequent cultivations. To test the value of this practice, the central section of each of 19 rows was holed prior to planting; whereas the sections of each side were left level. The average production per plant of corms or tubers suitable for table use was greater for the holed section in all but 2 of the 19 rows. Inequality in field conditions which was not apparent prior to planting affected the growth to a greater extent than did the planting methods tested. The tests are therefore being repeated.

A trial shipment of dasheens was made to New York in February. These tubers sold at 3½ cents a pound. A little more than 4 cents a pound was offered for tubers of similar quality in April. Considering the heavy production per acre in fertile soil—8 or 9 tons of tubers suitable for shipment and 2 or more tons of large corms suitable for local consumption—it is thought that the crop promises profitable returns to the grower. Shipments in the early fall or the late spring are advisable rather than in midwinter, when supplies from elsewhere are abundant.

The effect on production of planting Penang taro cormels of different sizes has been tested for four years. The sizes of cormels planted though varying slightly in the course of the test have been approximately 2 ounces or less for the smallest size, 3 ounces for the second, 4 to 5 ounces for the third, and 6 to 11 ounces for the largest size. Considering the four years' production as a whole, it is seen that the difference in yield has been insignificant. The highest yield has been obtained from planting cormels weighing 2 ounces or less, the second highest from cormels of 3 ounces, and the lowest yield from the cormels of largest size. The extremes differed by about 8 per cent. The annual yields individually have not held to a uniform sequence, but have varied from year to year, the production from the smallest and from the largest cormels having held first place one year and last place another. Evidently the yield of Penang taro has not been significantly affected by the size of cormel planted. As the large cormels not only are valuable as food, but are more likely to rot than are the smaller cormels, the latter should be preferred to the former for planting.

### YAMS

Selections were made from the lowest and highest yielding plants of yams to test different strains for productivity. The selected plants ranged in weight of tubers from 4 ounces to 2 pounds 14 ounces for those of lowest yield, and from 4 pounds 1 ounce to 8 pounds 10 ounces for the plants of highest yield. Each selection was planted separately. Either small whole tubers were planted, or larger tubers were cut to secure uniformity in weight of seed piece within the variety. Of six varieties included in the test, five showed on the whole a higher average production by the progeny derived from the low-yielding hills. In the following planting such strains as appeared to be of promise were retained, and some new selections were made to continue the test a second season.

### COCONUTS

At the Harvey coconut plantation, palms receiving 5 pounds of salt twice annually produced an average of 63 nuts per palm, whereas the unsalted palms constituting the check produced 61.9 nuts per palm for the year ending December, 1927. This was a reduction in yield over that of the preceding year of 5.5 nuts per palm in the plat receiving salt, and 11 nuts per palm in the check plat. Fertilizer applications to these plats were discontinued in January, 1926, and salt was applied for the first time in May, 1926, the new plats running crosswise of the old. At Corsica a fertilizer experiment has now been in progress for six years. In comparing the production of the first two years with that of the last two years, it is seen that the yield of the check remained stationary, whereas all of the fertilized plats show an increase in yield. This increase amounted to 13 and 23 per cent for the plats receiving incomplete fertilizer, and 29 and 91 per cent for those receiving complete fertilizer.

### VIOLET TREE

Seeds of the endemic, indigenous, and now very rare violet tree (*Phlebotania cowellii*), were secured and planted, and the resultant seedlings are thriving. This tree, beautiful for its flowers and valuable for its very hard wood, has for a long time seemed to be in danger of becoming extinct.

## REPORT OF THE PLANT BREEDER

By R. L. Davis

### FIELD CORN

Selfed lines were continued from high-yielding ears from the various districts. Number 6–7–3, a particularly promising line from Morovis, produced ears that in total length per plant exceeded those of normal open-pollinated corn. As was the case in previous years, the most vigorous lines, regardless of the number of generations selfed, came from Castillear–1, a champion high-yielding parent ear which was collected at Penuelas. These lines from Penuelas are very slow in approaching uniformity. Castillear 1–5–2–4–5 after four generations of inbreeding shows considerable variation in type and color of kernel, and in number of kernel rows. In contrast to this, Vincens-Flint 2–4–1–2–5, a line which has been inbred to the same extent but was derived from another source, is nearly uniform, all the kernels being flinty and of orange color, and nine-tenths of the ears being 10-rowed.

The lines thus far isolated from the upland districts near Barranquitas and Aibonito have not, when grown at Mayaguez, shown vigor at all comparable with those from lowland districts. They do not appear to be adapted to the lower altitude. Their plant growth is large, but the ears developed are not sound. Lines that grow vigorously at Mayaguez have been isolated from the four lowland districts, Coamo, Lajas, Morovis, and Penuelas, where selections have been made. Selection No. 12–13–1 from Coamo is outstanding for its long ears, and it is very nearly uniform for a dimple dent type of kernel.

White-kernel lines have been isolated from Lajas, Morovis, Jayuya, Penuelas, Coamo, and Barranquitas. In each instance where planted next to yellow sister lines inbred the same number of generations, the white recessives have made an inferior plant growth and proved to be more susceptible to disease.

Twenty-five first-generation hybrids were produced by crossing yellow-kerneled lines selfed for two generations with C.–1–2–4–6, a white-kerneled line selfed for three generations. This white line makes a very inferior plant growth and produces small ears and small kernels. Because of its decided inferiority, the white line was thought to afford a good test for the degree of prepotency in the yellow lines, as only the most dominant yellow type could give a high yield in the $F_1$ combination. In a test by the hill check method in which common corn from the Yauco-Torre farms was used as the

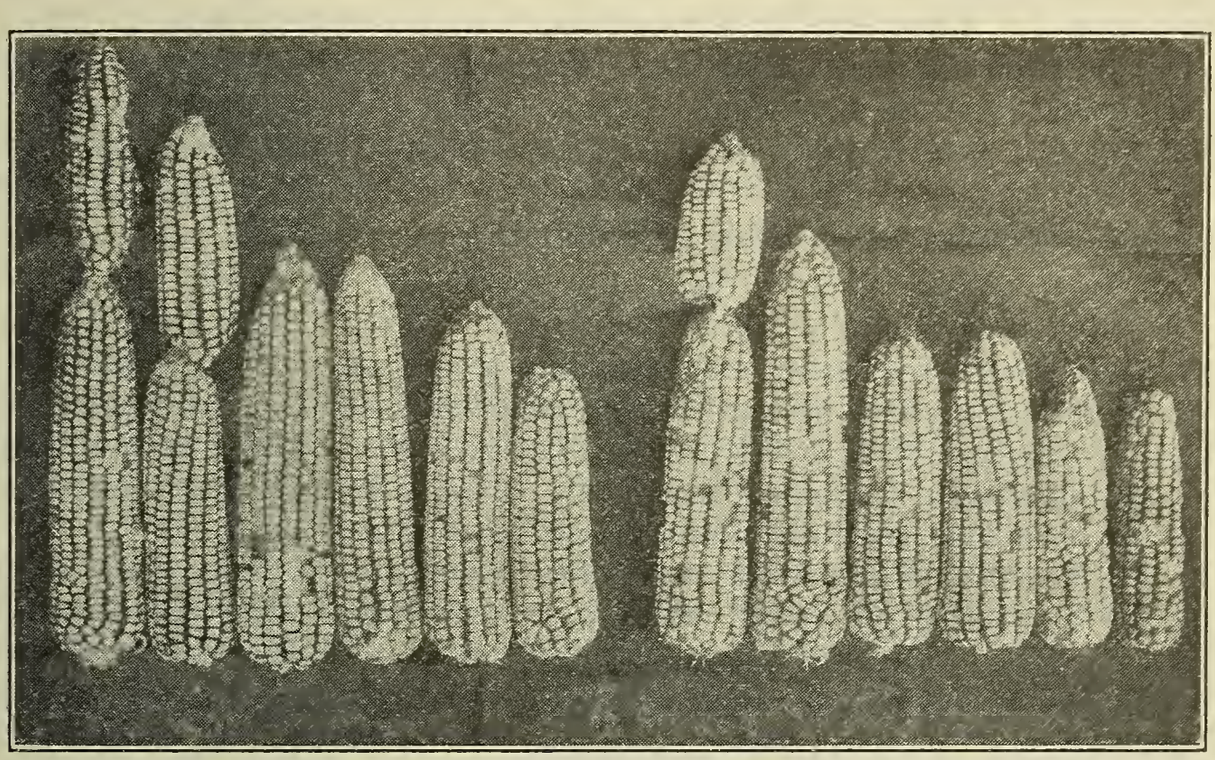

FIGURE 6.—Selfed lines with high total ear length tend to produce high-yielding hybrids. Left, hybrid of pistillate parent averaging 21.2 centimeters in ear length. Exceeded check in yield by 59.7 per cent. Right, hybrid of pistillate parent averaging 15.5 centimeters in ear length. Yield 4.2 per cent less than check

standard, two interesting observations were noted, the similarity in performance of hybrids from sister lines originating from the same parent ear, and the greater prepotency of yellow lines that had made superior plant growth in the pure inbred condition. The hybrids from the sister lines, Barranquitas 22–11–1 and 22–11–2, are both low in prepotency, yielding less than 95 per cent of the check in shelled corn per acre. The same is true of hybrids from two sister lines of Castillear–1–o–p.–21, which yielded, respectively, 81.4 and 95.8 per cent of the check.

As an example of parallel performance for high prepotency, four sister lines from Castillear–1–o.–p.–50 all outyielded the check by 7 per cent or more. Of eight lines which were superior for plant growth, five were also superior to the check in first-generation hybrid combination. The average total ear length of the lines was a better criterion than plant growth for predicting prepotency, since the pistillate parents of eight of nine high-yielding hybrids were superior for total ear length. Figure 6 shows ears from two hybrids whose

pistillate parents were derived from the same parent ear. Ears from six representative plants are shown in each instance. The hybrid on the left exceeded the check in yield of shelled corn by 59.7 per cent, and its pistillate parent averaged 21.2 centimeters in total ear length. The hybrid on the right yielded 4.2 per cent less than the check, and its pistillate parent averaged only 15.5 centimeters in total ear length.

### SWEET CORN

The growth of Mayaguez–1, a sweet corn which was developed from native field corn and distributed in 1928 for the first time, has not been wholly satisfactory in the dry districts of Porto Rico. Several vigorous inbred lines that are derived from the same source as Mayaguez–1 offer a solution to this difficulty, because in their inbred condition they grow taller and produce larger ears than Mayaguez–1. They are first-generation selfed lines from 27 Su–12 that grew fully 1½ feet taller than Mayaguez–1 in the spring of 1928. It is probable, however, that some trouble will be experienced in selecting for tender kernels. In this respect these lines are less promising. Crosses have been made between native sweet corn and the most vigorous selfed lines of field corn.

### SUGARCANE

Several very promising importations were made during the year. P. O. J. 2364, supplied by the Bureau of Plant Industry of the United States Department of Agriculture, and Ba 6835, sent from Trinidad, are very desirable breeding material. The best varieties developed in both Java and Barbados have been bred from them.

P. O. J. 2878, from Java, has been propagated with the utmost rapidity and extended to all parts of Porto Rico. The Java water-sucker method was used in combination with the Mayaguez single-eye method to accelerate propagation. From three single eyes that germinated in March, 1927, 10 acres were planted in July, 1928. P. O. J. 2878 has given very good first ratoons at Mayaguez and is a prolific stooler, even exceeding P. O. J. 2725 in this last respect. P. O. J. 2878 does not have the objectionable feature of early arrowing. Ten-month-old "primavera"[3] and 14-month-old "gran cultura"[4] plantings of P. O. J. 2878 did not arrow, whereas, in adjoining plantings of corresponding age every cane of P. O. J. 2725 arrowed. In two small "primavera" plats P. O. J. 2878 outgrew P. O. J. 2725 by a substantial margin of nearly 2 feet. P. O. J. 2878 responds well to good cultural conditions and at Mayaguez produced canes of large diameter with joints averaging 7 inches long. It is very susceptible to the cane borer, a fact which may cause trouble in the dry districts where this pest is prevalent. The first analyses made on January 17 at Mayaguez indicate that P. O. J. 2878 is late in ripening. The juice of 15-month-old "gran cultura" from the original three stools propagated here had, on analysis, 14.1 per cent

[3] Spring planting of cane usually cut when 12 to 13 months old.
[4] Summer or fall planting of cane usually allowed to grow for 15 to 18 months before it is harvested.

sucrose and a purity of 84.2 per cent. This was several points lower than that of a seedling of S. C. 12/4 growing in the same plat. The juice of 10½-month-old "primavera" contained 14.27 per cent sucrose and had a purity of 83.7 per cent, whereas the juice of adjoining stools of P. O. J. 2725 showed on analysis 14.75 per cent sucrose and a purity of 85 per cent. The season during which these canes ripened was exceedingly adverse because of rain, which depressed the sucrose and caused the buds to shoot in the standing cane.

Of the second-year and third-year selections from hybrids between P. O. J. 2725 and S. C. 12/4, the more promising at present appear to be Mayaguez 28, 42, 44, 51, 3, 7, and 63, all of which are highly resistant to mosaic. Mayaguez 28 holds the record on sucrose at Mayaguez, exceeding that of all varieties analyzed in 1926 and in 1927. At Central Eureka, Central Coloso, and Mayaguez, this hybrid has made a growth equaling that of P. O. J. 2725 and B. H. 10/12. It stools even better than P. O. J. 2725, sheds its leaves freely, and produces canes of good diameter. Mayaguez 28 has two drawbacks: It arrows profusely, though not so early as P. O. J. 2725, and the buds shoot out badly toward maturity, making top seed undesirable for planting.

Mayaguez 42 appears to be the most promising of the 1927 hybrid seedlings. In January, 10½-month-old canes analyzed 17.62 per cent sucrose and a purity of 89.3 per cent, equaling tests on P. O. J. 2725 of the same age. Mayaguez 42 has outgrown P. O. J. 2725 in "primavera" planting, and produces canes of good girth, with extra long joints similar to those of P. O. J. 2878. It germinates well, has not arrowed at Mayaguez, and does not have hairs on the leaf sheaths.

Of all the hybrids, Mayaguez 44 most closely resembles P. O. J. 2725. It is, however, sweeter than the mother variety, and is probably much later in arrowing. It has long yellowish-green joints and broad light-green leaves that are shed very freely.

Mayaguez 51 is practically the same as P. O. J. 2725 in time of arrowing. Its growth is erect, and it sheds its leaves freely and resists wet land. It grows very rapidly and has in preliminary trials exceeded the height of P. O. J. 2725 in adjoining rows by several feet. Mayaguez 51 is outstanding for its vigorous ratoons. The canes are very long jointed, green to yellowish-green, and of a satisfactory girth, somewhat less than that of S. C. 12/4. Its juice has a sucrose content about equal to that of P. O. J. 2725.

Mayaguez 3 has for the second year outgrown B. H. 10/12 at Central Pagán, Anasco, where cooperative tests with the South Porto Rico Sugar Co. have been carried on. It is outstanding for its erect growth and tough canes of medium girth which are free from borer attack. Mayaguez 3 was germinated at the Fajardo Central experiment station and sent to the Mayaguez station while still in the germination flat in January, 1926. It is of interest to note that this seedling was at 1 month several inches taller than were any of the others in the same germination flat. Additional tests on its sucrose are needed. The first-year analysis was lower than that of P. O. J. 2725.

Mayaguez 7, which gave a low sucrose as a first-year seedling, has had promising analyses in the "gran cultura" wet-land experiment

at Mayaguez. In two plats it had an analysis on January 17 of 17.2 per cent sucrose and 17.61 per cent sucrose, respectively, whereas in P. O. J. 2725 the sucrose averaged 15.82 per cent. The purity of the juice of both varieties was about 88 per cent. Mayaguez 7 has not arrowed for three seasons at Mayaguez. It makes a rapid early growth and resists drought well. Like most of the other hybrids, it has long joints. The canes are somewhat smaller in girth than those of P. O. J. 2725 and not so erect as those of Mayaguez 3.

Of all these hybrids, Mayaguez 63 has the toughest foliage and the healthiest stools. It is a thick green cane with long joints and round buds which are well confined to the growth ring. It has withstood drought and adverse wet-land conditions well during the past two years. In young "primavera" it analyzed somewhat better than both P. O. J. 2725 and P. O. J. 2878. On January 17 "gran cultura" plantings in a very poorly drained field yielded 2 per cent less sucrose than did P. O. J. 2725. Like H. 109, B. H. 10/12, and other commercial varieties, the canes become increasingly large toward the top. Mayaguez 63, when planted next to P. O. J. 2725, made a growth at 16 months that was not inferior to that of the latter. No signs of arrowing have been observed.

The new seedlings propagated include over 1,000 selfed seedlings of B. H. 10/12, 400 crosses between B. H. 10/12 and D. 433, 50 selfed seedlings from E. K. 28, and 4 crosses between P. O. J. 2725 and Ba. 11569. In addition, selfed seedlings from Ba. 11569, D. 1135, and S. C. 12/4 were bred. The new crosses showed no promise and were discarded. Of the selfed seedlings, those of E. K. 28, Ba. 11569, and B. H. 10/12 made the best growth. Several of the B. H. 10/12 seedlings have equaled the growth of the best seedlings of E. K. 28 and are, in addition, decidedly healthier.

The principal effort in seedling propagation work for the year was centered on the problem of variable viability of sugarcane seed from arrows of the same variety. Collections of 50 arrows of S. C. 12/4 per district were made near Toa Baja, Fajardo, Humacao, Yabucoa, Manati, Arroyo, Guayama, and Ponce. The lowest germinations secured were 7 seedlings per arrow from Central Mercedita, Ponce, with no December rainfall and 3.3 seedlings per arrow from Central Aguirre near Guayama with a December rainfall of 0.06 inches. The best germinations were 134 seedlings per arrow from Yabucoa with a December rainfall of 2.19 inches, and 135 seedlings per arrow from Manati with a December rainfall of 4.78 inches. Satisfactory germinations were secured from all the other districts excepting Arroyo, where the December rainfall was very light. These data indicate that viable seed may be secured in Mayaguez and other districts that are dry during the propagation season, provided that irrigation water is applied during the periods of blossoming and maturation from November 10 to December 20. Watering the arrows gently with a fine spray from 9 a. m. to 3 p. m. during the pollination and early maturation periods reduced the germination by half. This indicates that irrigation water alone is sufficient under the natural humidity prevailing at Mayaguez during the critical period.

## REPORT OF THE AGRICULTURIST

By H. C. Henricksen

### PINEAPPLE INVESTIGATIONS

The pineapple investigations were continued. Several new problems were attacked, and those of immediate practical importance, relating to maturity and the shipping of the fruit, were solved. The results were published in mimeographed numbers of Agricultural Notes issued by the station in order that local planters might derive immediate benefit from the findings.

Extensive cooperative field experiments were started in 1927 with the object of testing a number of methods by which the time of fruiting might be controlled.

In experiments in plant selection which have been under way for several years, the results show that such characteristics as size and vigor of plant, and size and usually the shape of fruit are transmitted from generation to generation. This was explained to planters at field meetings, and as a result several have been practicing plant selection for the past few years.

One phase of selection of very great importance to the pineapple industry in Porto Rico is the elimination of the barren type of plant locally known as " Riñon " or " Macho." This type was first noticed about 12 years ago. Since then experimental results show that 100 per cent of the plants transmit a characteristic vigorous growth with a production of very small, usually misshapen fruits which are edible but commercially valueless. This problem was very serious until the planters were made aware of it, for the plants being vegetative, produced a large number of vigorous slips which were eagerly selected for further planting. As a result, some of the plantations were producing 25 per cent or more of worthless plants before the growers became aware of the fact.

Another seemingly promising phase of selection has so far been deferred because of lack of assistance. It is generally known that some fruit is sweeter and of much better quality than other fruit. Difference in sweetness has been thought to be due partly to environment and partly to difference in maturity of fruit. That this is not entirely correct was well demonstrated in these investigations when occasional fruits were found containing nearly 2 per cent more total solids than did average fruit of equal maturity. This would seem to indicate that quality is a very promising characteristic for use in selective breeding work.

### OUTWARD INDICATIONS OF FRUIT MATURITY

The outward indications of fruit maturity are very difficult to recognize. The disappearance of chlorophyll from the rind while a sure indication of maturity of fruit is of minor practical value because most of the fruit is picked before it reaches this stage. Although plant-ripened fruit is most desirable for consumption it is not so suitable for long-distance shipment as is fruit that is less mature. On the other hand, maturity must be well advanced before the fruit is picked, or the quality will be very poor. Two stages of maturity of the Red Spanish variety are readily discernible regard-

less of local conditions. One concerns the appearance of the bract or leaflet at the base of each eye. So long as the bract remains unwilted, the fruit has not matured sufficiently to have attained a high degree of palatability. The other stage concerns the color of the basal eyes. When they show a slight yellowing the fruit is of shipping maturity, but is too mature for long-distance shipment except under refrigeration.

Between the two extreme stages of maturity are several indications which vary with soil, fertilizer, moisture, and temperature. They are different, therefore, on different plantations and can be recognized only by those who are familiar with local conditions.

### STAGES OF MATURITY

The stages of maturity are discernible in the texture and flavor of the flesh and in the color, taste, viscosity, and total solids content of the juice. The flesh of the immature fruit is firm and brittle and practically without pineapple flavor. As the flesh becomes increasingly tender toward maturity it develops the typical pineapple flavor.

The juice of the immature fruit is milky white in color, insipid in taste, very viscous, and has a total solids content of 9 per cent or less. As maturity progresses the color changes to yellow, the taste mellows, the viscousness greatly diminishes, and the solids content increases. The latter is usually 14 to 15 per cent in the juice of the plant-ripened fruit, and in exceptional cases it may reach 16 to 17 per cent, the basal portion containing 2 to 4 per cent more than the apex. These changes take place only in unpicked fruit. After the fruit is severed from the plant, sugar formation stops. This was definitely proved in these investigations by the removal of plugs from the fruit at several intervals and the testing of the juice in an Abbé refractometer. The plugs were removed under aseptic conditions, and the resultant cavities were filled with melted paraffin to prohibit infection. This, it was found, did not interfere with the maturity changes in the fruit.

The acidity was measured by titration and found to vary from less than 0.4 per cent in the immature fruit to upward of 0.9 per cent and occasionally more in the mature fruit. The variations were not consistent enough, however, to permit using acidity as a reliable measure of maturity.

### FRUIT DECAY

One of the most serious causes of loss to the pineapple grower is decay in transit. Decay in the pineapple is brought about by the same agents producing it in other kinds of fruit, but the effect is aggravated by the very perishable nature of the mature pineapple. For this reason most of the growers are inclined to ship immature fruit. The results of investigations at the station show that plant-ripened fruit, when it is properly handled, can be safely shipped at a temperature of 35° to 40° F.

The so-called black rot of pineapples is difficult to prevent. It is usually caused by a fungus entering the stem end of the fruit after it is cut from the plant, but an overabundance of water in the fruit is always a contributory cause. Black rot is not very prevalent except

in rainy weather. It can be largely eliminated by thoroughly drying the stem scar. Sun drying is preferable, but artificial drying must be employed in cloudy weather. Several methods of artificial drying have been perfected, employing a blast of air with or without heat. One of the growers has constructed a series of frames 6 to 7 feet high, under which he sets the fruit on the ground with the stem end exposed to the sun. A covering is drawn over each frame when rain commences and is removed when it ceases.

### CITRUS INVESTIGATIONS

It became necessary during the year to devote considerable time to citrus problems. Coloring and washing of the fruit, together with some other packing-house problems were investigated. A preliminary report on the results obtained was published in mimeographed form in Agricultural Notes No. 40, issued by the station.

### IDENTIFICATION OF BUDDING STOCK

A survey of the citrus groves was started. One of the first difficulties encountered in the work was the determination of the stock upon which the trees are budded, the sprouts which emanate from below the bud union and are seldom present being the only sure indication available. This difficulty was overcome by the finding of a chemical method making it possible to differentiate between the stocks that have been planted in Porto Rico. These are rough lemon, sour orange, cultivated grapefruit, and occasionally the so-called native grapefruit.

The method is based upon the depth of color produced by ferric chloride when it is added to an aqueous solution of root tissue. A method, simple enough for planters to use, was described in mimeographed form in Agricultural Notes No. 43, published by the station.

In the laboratory the following method was satisfactorily used: A piece of root was washed and dried, and the bark was scraped from it. A 1-gram sample was macerated in a mortar with a few cubic centimeters of water, after which about 20 cubic centimeters of water was added. One cubic centimeter of a 5 per cent ferric chloride solution was next added and the whole stirred well. A small portion of aluminum cream was added and the mixture filtered on a small Buchner filter. The solution of the volume of the filtrate should be 50 cubic centimeters or greater, depending upon its color. The depth of the color was determined in a colorimeter in comparison with a standard solution of naringin to which ferric chloride had been added. Rough lemon showed practically no color; native grapefruit had a color equaling 4 to 6 milligrams naringin in a 50 cubic centimeter solution; cultivated grapefruit had a variable color, but usually it was equal to more than 6 milligrams and less than 10 milligrams naringin; sour orange had a very variable color, but it nearly always was equal to more than 10 milligrams naringin. This showed that rough lemon and sour orange, the two stocks commonly found in Porto Rico to-day, can readily be distinguished from each other. The native grapefruit is readily distinguished from the two former, but it can not always be so readily distinguished from some varieties

of the cultivated grapefruit. The sweet orange has seldom, if ever, been used for stock here. It will present difficulties whenever it is found because the various varieties produce a depth of color which shades into those of the different strains of the sour orange.

### POT AND LYSIMETER EXPERIMENTS

Five series of sand cultures, each made up of six 10-quart containers planted with grapefruit seedlings, were under observation for five months to determine the optimum salt concentrations and changes in pH taking place as the result of applying different nutrient solutions to them. The results were practically negative because of poor plant development, in this respect paralleling the results obtained by Breazeale.[5]

Twenty-four half barrels were filled with a uniform grade of sandy clay soil which was practically devoid of organic matter and available plant nutrients. Each container was planted with six citrus seedlings which were about 3 inches tall, and various mixtures of inorganic fertilizer salts were applied to the soil. The experiments were continued for eight months, during which time the soil was tested for nitrogen and pH and the plants were measured. No definite results were obtained from the plant measurements as differences between individual plants in any one series were greater than those between plants in different series.

The pH of the soil was 6.3 at the beginning of the experiment and dropped to 5.3 in less than three months in the series receiving ammonium sulphate and potassium sulphate. In the next series, which received calcium phosphate in addition to these two substances, the pH remained practically stationary. In the series receiving urea and potassium phosphate, the pH remained practically stationary. In another series, in which sodium nitrate was substituted for urea, the pH increased slightly. These results indicate that the changes in pH were caused by such ions of the various salts as were not taken up by the plants.

In one series, which received sulphur at the rate of 1 ton per acre in addition to complete fertilizer, a pH of 3.8 was produced within two months. Some of the plants were killed outright; the rest made very little growth. Replantings were made from time to time, but growth was practically nil as the pH remained around 4. This indicates that the critical soil pH for citrus trees lies between 4 and 5.

In another series, which received air-slaked lime at the rate of 1 ton per acre, the pH was barely raised beyond 7, and it did not affect plant development.

The nitrogen determinations were made for the purpose of ascertaining to what degree nitrogen may be depleted before plant growth ceases. The results were not conclusive. On some plants new leaves were formed when the nitrate content of the soil was only 2 parts per million and the ammonia content 4 parts per million. This, however, is no indication of what the minimum content may be in commercial plantations.

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[5] BREAZEALE, J. F. VITAMIN-LIKE SUBSTANCES IN PLANT NUTRITION. Ariz. Agr. Expt. Sta. Tech. Bul. 16; p. [401]–417, illus. 1927.

After eight months some of the plants from each series were ashed and analyzed for calcium, potassium, and phosphorus. The results did not show differences that could be attributed to the fertilizers applied, but consistent differences in the ash content were apparent between the species, grapefruit and lemon containing on an average 1.5 per cent more of these substances than the sour orange.

Another result worth recording is the difference in ash content of the leaves and the stem, the former containing more than twice as much as the latter regardless of the species or the fertilizer applied.

In a third experiment, which is being carried on along the same line as the former, 50 citrus trees, each in an iron drum of 30-gallon capacity containing the same grade of soil as that used in the half barrels, are under test. The drums are so placed as to permit collection of the drainage water and are provided with practically rainproof covers when necessary. This experiment is to be continued for several years, until the trees become pot-bound, in the hope of ultimately obtaining data on optimum soil moisture, plant nutrients and pH for citrus, and the differences, if any, in these factors in relation to lemon, grapefruit, and sour orange.

### FRUIT GROWERS' MEETINGS

The agriculturist acted as secretary of the fruit growers' meetings and attended the get-together luncheons which were given monthly in San Juan. Mimeographed records of these meetings, which have been sent out during the past three years, have been greatly appreciated by the fruit growers.

## REPORT OF THE PLANT PATHOLOGIST

By C. M. Tucker

### AVOCADO ROOT DISEASE

Investigations on a root disease of avocados were continued. During the year trees in a commercial planting of Mexican and Guatemalan varieties which had been grafted on West Indian stocks at Villalba were found to be dying. The earliest symptoms of disease were a cessation of growth and the appearance of a yellowish, unhealthy color of foliage, which was followed by gradual defoliation and death.

Trees of all ages from young seedlings to large trees 6 to 8 years old bearing full crops of fruit were attacked. The infected seedlings were in a nursery which had been established in a section of the grove whence dead trees had been removed. The seedlings were in rows, and circular areas of dead or dying seedlings were to be found at places where infected trees had grown. The size of the infected areas corresponded rather closely to the root spread of the removed trees.

Cultures were made from roots from six infected trees, and five of them yielded a Phytophthora which was identical morphologically with the fungus that was repeatedly isolated from trees showing the same disease symptoms at the station. (Fig. 7.) The Phytophthora closely resembles *P. cinnamomi*. The species is well differentiated by the production of grapelike clusters of chlamydospores and the ab-

sence, in ordinary cultures, of zoosporangia and oospores. There is some evidence, however, that the avocado strain differs from cinnamon strains in pathogenicity.

Inoculation experiments on West Indian seedlings grown in autoclaved soil demonstrated the ability of the fungus to attack and kill the roots. In most instances the effect of the parasite is rather slow. Of six plants that were inoculated January 30, 1928, four were dead

FIGURE 7.—Young Dickinson avocado grafted on West Indian stock dying from root disease. Located on a hillside in heavy clay soil

on July 7, 1928. The two living plants had made no growth. The check plants were healthy and growing vigorously. (Fig. 8.)

Examination of the roots of healthy and diseased plants revealed that practically all the roots of the inoculated plants had rotted. In Figure 9 the roots of an infected plant (on the left) were taken from a badly wilted plant which was barely kept alive by the proliferation of small, weak roots near the crown. Such roots seem to become infected rather early and seldom become sufficiently widespread to cause renewed growth.

The disease occurs frequently in heavy soils and in poorly drained locations. At the station young trees on fairly steep slopes have succumbed. The soil is a heavy clay. At Villalba the disease first appeared on a rather poorly drained plateau at the base of a precipitous slope from which the plateau received the run-off. The surface 15 inches of soil was a gravelly, friable loam. The subsoil was a yellow, tight clay. At this place many of the trees attained

FIGURE 8.—Inoculation experiments with avocado. Left, two check plants; right, inoculated January 20, 1928, and photographed July 7, 1928. The plants were of equal height at the beginning of the experiment

large size before they were killed. This fact was probably due to the favorable conditions encountered by the roots in the surface soil during the early life of the tree and to their infection upon reaching the impermeable subsoil.

It is apparent from the observations made that commercial plantings of avocados are most likely to succeed in places having a deep, permeable soil and good surface drainage. The degree of surface

and subsurface drainage necessary naturally varies considerably with the rainfall.

Observations indicate that infection and rotting of roots occur mostly during the rainy season. Attacked trees may, however, remain healthy in appearance until a few weeks after the beginning of the dry season when the reduced root system, under scanty moisture conditions, is no longer able to supply the necessary water to the plant.

### CITRUS SCAB

During the year a majority of the first generation Duncan-Triumph grapefruit hybrids came into bearing. The first-generation trees,

FIGURE 9.—Root disease of avocado. Left, root system of the plant on the left in Figure 8. Right, root system of the plant on the right in Figure 8. The only functioning roots are the few small ones arising near the crown

bred in an effort to obtain a desirable grapefruit having the scab-resistant character of the Triumph variety, proved to be as susceptible to scab as the susceptible parent Duncan.

Seeds from fruits of the hybrids were planted in boxes in January and the resultant seedlings transplanted to the nursery in April. About 3 acres of plants set 6 inches apart in rows 3 feet apart were obtained. Some of these second-generation seedlings were lost during the unusually heavy rains of the summer, but a large number of them are in very good condition. Scab infection has already appeared on the leaves and young stems, and the elimination of susceptible individuals will be begun in the spring of 1929 during the period when natural infection is most prevalent.

### PHYTOPHTHORA INVESTIGATIONS

The collection of Phytophthora species and strains maintained under culture was considerably increased by acquisitions from other investigators, and many requests for cultures were granted. Investigations into the pathogenicity and morphology of the strains were continued.

Of special interest are two diseases caused by fungi of this genus found during the year for the first time in Porto Rico. In April, following a period of very heavy rains, an outbreak of a severe epidemic among pepper plants was observed. The plants were 3 to 12 inches tall. The fungus invaded the tender stem tips and the leaves. Attacked stems turned black, shrank, and collapsed. Spots one-half inch in diameter to larger ones involving the entire area were found on the leaves. The spots were brownish green in color and became dry and parchmentlike. Infected leaves fell prematurely from the plants. The mortality among the plants was about 60 per cent. Infected plants seldom recovered. On the blackened stems zoosporangia were produced in great profusion presenting a whitish, mealy appearance. From these stems the causal Phytophthora was isolated and the disease reproduced by inoculations. Wound inoculations of pepper stems near the soil level resulted in the death of the plants in three days.

Many of the fallen grapefruits which had lain on wet soil for several days were damaged by a rot which began on the side in contact with the soil. The fruit remained fairly firm in texture, and the brown-invaded areas of skin became somewhat leathery. Fruits showing initial stages of infection were entirely invaded and covered with a white cottony growth of mycelium after three days in a moist chamber. The mycelium produced a few chlamydospores, but zoosporangia were rarely seen. In culture the Phytophthora differs morphologically from *P. citrophthora*, the common brown-rot fungus of California. In Australia a brown rot of citrus is caused by *P. hibernalis*, which differs both morphologically and physiologically from the Porto Rico isolation.

Infections of fruits on the trees have not been observed, and the soil is apparently the usual habitat of the fungus. Occasional cases of brown rot recorded on Porto Rican fruit in the New York market are believed to have been the result of shipping fallen fruit or of allowing the fruit to come in contact with moist soil.

### POKKAH BOENG DISEASE OF SUGARCANE

The sugarcane disease known as pokkah boeng,[6] which is common in Java, and in Louisiana, Cuba, and Hawaii, especially on recently introduced Java seedlings, was observed at the station in January, 1927, on a hybrid produced by crossing P. O. J. 2725 and S. C. 12/4.

The symptoms of the disease in Porto Rico agree in certain respects with descriptions of those occurring in Java and Cuba. Chlorotic spots on the leaves, usually near the base, are said to be the earliest symptom. These spots are apparent on unrolling leaves and are

[6] Javanese words signifying "damaged top."

not developed on expanded leaves. In some instances wrinkling of the chlorotic areas occurs; in others, there is no distortion, and in yet other instances conspicuous wrinkling occurs on otherwise apparently normal green tissue. In some instances a chlorotic wrinkled area may appear near the base of a leaf and on the succeeding leaf a wrinkling of similar pattern may appear about half way between the base and the tip, whereas, in the second succeeding leaf the wrinkling may appear near the tip. The position of the wrinkled areas indicates that the wrinkling occurred while those areas were in close contact in the leaf spindle.

The chlorotic areas usually show red or reddish-brown spots or streaks soon after the leaf unrolls. In Java and Cuba a further stage of the disease is said to be a top rot. In Java the infection is reported to extend into the stalk below the growing point, where it causes cavities and strands of reddish tissues which are crossed by dark bands, producing a ladderlike appearance. These latter symptoms have not been observed in Porto Rico.

The varieties on which the chlorotic spots most frequently appear are the Java canes produced by crosses between P. O. J. 2364 and E. K. 28, and on crosses between the progeny of this cross and other varieties. Among the progeny of the P. O. J. 2364 and E. K. 28 cross the varieties P. O. J. 2725, P. O. J. 2714, P. O. J. 2878, and others are susceptible. Of these, the P. O. J. 2878 seems to be the most frequently affected. Crosses between P. O. J. 2725 and S. C. 12/4 are very frequently affected. The stool on which the disease was first noticed, carried in the station records as J. S. C. 363, showed the chlorotic spots more conspicuously than did either P. O. J. 2725 or P. O. J. 2878. A number of other seedlings produced by the station and by the Fajardo Sugar Co. produce leaves similarly affected. Other varieties occasionally produce leaves with slightly chlorotic spots, but no distortion has been observed.

The effect of the disease on the cane is problematical. At the station a planting of P. O. J. 2878 made in March, 1927, began to show chlorotic spots in June of the same year. The cane continued to make apparently normal growth to maturity. Ratoons from these stools showed no abnormalities until they reached a height of 4 to 5 feet. They, too, then began to produce occasional leaves showing the typical chlorotic area near the base. These ratoons are now mature. No cases of top rot have occurred, and, so far as it can be determined, the cane has not been injured.

The first planting of P. O. J. 2878 for commercial purposes was made by the Coloso Sugar Co. near Aguadilla. The cane was being propagated continuously, and the planting contained stools of various heights ranging from a few inches to 9 or 10 feet. Each stool was examined carefully for evidences of infection. The planting contained 685 stools, of which 73 were found to have a chlorotic area at the base of one or more leaves. In 12 instances reddish brown discolorations were observed in the chlorotic areas, usually being accompanied by splitting of the tissue.

In the planting 33 cases of top rot (dead growing point) were found. Of these, 25 occurred among very young canes and were caused by insect pests, usually the mole cricket and in a few instances the moth borer. The insects had fed upon the young leaves in the

leaf spindle or the growing point. Of the 8 cases found among older canes, 5 were caused by the moth borer and 3 were due to some undetermined cause. Of the latter, two occurred on stalks which showed no evidence of pokkah boeng. The third occurred on a stalk having three leaves with chlorotic markings.

Very young stools less than 2 feet tall showed no disease. Symptoms were observed on 6 stools 2 to 3 feet high, 5 stools 4 to 5 feet high, 3 stools 6 to 7 feet high, and 59 stools 8 to 10 feet high.

Among the stools 2 to 3 feet tall only traces of chlorotic areas could be seen. The distribution of the entire population into the different height classes was not made, but the class 2 to 3 feet tall appeared to be the largest.

The above observations were made following a season of abnormally wet weather which would appear to favor infections. Of interest in this connection was the appearance of a red stripe disease, probably bacterial in nature, on the emerging leaves on four stalks. The latter disease is probably identical with one previously observed on B. H. 10/12.

Small plantings of P. O. J. 2878 have been made in many sections. Visits were made by the plant pathologist to some of the oldest of these at Santa Rita, Fortuna, Central Mercedita, Aguirre, Caguas, Humacao, and Fajardo. At each place cane 8 feet or more in height was growing. In every instance some chlorotic leaf bases could be found. No cases of top rot were seen, and no evidence could be obtained that any had ever occurred. The plantings of this variety were being watched with much interest and it is unlikely therefore that a dead top would have escaped notice.

Isolations from the reddish discolored tissue from chlorotic spots yielded two Fusarium strains. Fusaria were present in about 90 per cent of the approximately 200 platings examined. The two strains were obtained in almost equal numbers.

Since the chlorotic areas are reported to be the earliest symptom of invasion, it was considered probable that the causal organism might be obtained from young chlorotic spots with most certainty. Accordingly, more than 200 platings of young spots showing no reddish or brownish discolorations were made. The tissues plated were obtained from the varieties P. O. J. 2878, F. C. 933, F. C. 915, F. C. 937, B417, and M. P. R. 14. The plantings from which the leaves were obtained were located at Mayaguez, Santa Rita, Fajardo, Central Mercedita, Humacao, Caguas, and Fortuna. In no instance was a Fusarium obtained.

At the same time nearly 50 pieces of tissue of P. O. J. 2878 showing discoloration were plated, and Fusaria were obtained from 93 per cent.

Inoculation experiments have shown that the Fusaria are very weak parasites capable of causing only insignificant lesions even when placed on the wounded central roll of young leaves and kept constantly wet. No traces of chlorotic spots resulted. Inoculations of cuttings by injections of suspensions of the fungi failed to produce the disease in the daughter plants, or to affect the germination of the cuttings. Efforts to transmit the disease by planting cuttings from diseased stalks were not successful. The investigations are being continued.

## REPORT OF THE PARASITOLOGIST

By H. L. Van Volkenberg

### GENERAL SURVEY

Several species of internal parasites of horses were collected during the year. Post-mortem examination of one horse and two mules from the same locality revealed the presence of nose bot-fly larvae in the stomach, tapeworms, pinworms, and several species of Strongylinae in the intestines, a filarial worm in the peritoneal cavity, an Onchocerca in the cervical ligament, and lungworms in one of the mules. A worm aneurism was found in the anterior mesenteric artery of the horse.

Demodectic mange mites have been collected several times from swine. Observations made at the local abattoir indicate that this mange is not uncommon.

*Cysticercus cellulosæ* was again observed. Of a total of 6,323 hogs which were slaughtered during 1928, 8 carcasses were condemned at the local abattoir on account of this parasite.

In May, six native pigs about 1 month of age were purchased at the local market. Within two weeks five of them died from an infection with *Balantidium coli*. Ulcers were extensively found, especially in the caecum of the animals. The sixth pig, although it was kept in a small pen with two of the others, did not become sick.

Manson's eye worm has been found frequently this year in autopsies made on poultry. The air-sac mite has also been found.

Screw-worm flies are a common pest. Any open wound in animals, unless treated at once, is likely to become infected with the larvae or maggots of the fly.

The leech is an intermittent parasite which does not receive sufficient attention. Most of the swampy lands used for pastures are infested with leeches. They attack any accessible portion of the body of cattle drinking or standing in the water. The permanent swamps of Porto Rico serve as reservoirs of infection for several serious parasites. They provide breeding places for mosquitoes attacking both animals and man and for the propagation of snails, including a species which transmits blood flukes to man and possibly to animals, and another which transmits the liver fluke to animals and occasionally to man.

### LIVER FLUKES

The snail (*Lymnæa cubensis*) is the intermediate host of the liver fluke (*Fasciola hepatica*) in Porto Rico. This has been demonstrated both by infecting this snail with the miracidia developed from the ova of the fluke and by infecting calves and rabbits with the resulting encysted cercariae. This snail is found in mud in swampy land and along shallow sluggish streams and drainage ditches. The specific identity of this snail was determined by Dr. Paul Bartsch, of the United States National Museum.

A small percentage of these snails was found to be infected with a stubby fork-tailed cercariae. *L. cubensis* and the snail *Planorbis guadeloupensis*, which transmits the blood fluke, *Schistosoma mansoni*, in man, were found to have similar habitats, although the latter

snail apparently has a wider distribution. Any campaign for snail eradication should include both species.

Examination showed that a very high percentage of *P. guadeloupensis* was infected with cercariae of five different kinds. One of these which encysts on fish was by far the most common. Snails infected with the intermediate stage of the blood fluke were collected several times at Cuatro Hermanos, at Mayaguez, in the vicinity of Anasco, and at Cartagena lagoon.

Experiments in the treatment for liver flukes were carried on. Heavily infested oxen which are brought to the local abattoir for meat purposes are being used in the studies. The animals weigh approximately 800 pounds each. The effect of the drug used is determined by an examination of the liver 3 to 10 days after the animals receive the last treatment. Large single doses of carbon tetrachloride (50 and 100 c. c.), tetrachlorethylene (50 c. c.), and carbon disulphide (20 c. c.) apparently had no effect whatever in destroying the flukes. This seems to be unusual, because single doses of 1 cubic centimeter of carbon tetrachloride are said to destroy all mature flukes in both sheep and goats. However, daily small doses have shown some efficiency. In one case 10 cubic centimeters daily over a period of 20 days destroyed all the flukes in a heavily infested animal. This work is being carried on as rapidly as suitable animals become available.

### SWINE KIDNEY WORM

*Life history.*—Under laboratory conditions the ova of *Stephanurus dentatus* hatch in 36 hours upward. The larvae reach the infective stage in four or more days after moulting twice. The infective larvae are ensheathed. Infection of the pig is easily accomplished by way of the mouth. The larvae pass to the portal vein and hepatic artery and their branches in the liver, where an intermediate stage of development is undergone. After these worms reach a length of approximately 15 millimeters they migrate from these vessels through the liver, usually to the fat surrounding the kidneys, and some eventually develop to maturity in cysts along the ureters and discharge ova through fistulous tracts into these tubes. The length of time between infection and appearance of the ova in the urine is about six months.

The developing worms in the portal vein and hepatic artery cause the formation of thrombi and diffuse aneurisms. In cases in which several or many larvae lodge and develop simultaneously in one area a sacculated aneurism forms. Often the migrating worms rest for a time close to or underneath the capsule of the liver, thus causing a pocket of pus to form. The abscesses and irritation caused by the worm later result in the formation of hard nodules; and often in heavily infested animals extensive areas of the liver are replaced by connective tissue. The migrating worms which enter the kidney probably through the hilus occasionally wander on through the cortex, producing hemorrhagic tracts which are later replaced by characteristic scar tissue. Some develop to maturity in the medulla and discharge ova into the pelvis of the kidney.

Often various-sized worms are found in small, round, thick-walled nodules in the parenchyma of the liver and in thrombi in the posterior vena cava where this vessel is embedded in the liver. Apparently these forms, differing from the actively migrating worms, remain in

these locations for some time and probably undergo some development, although a portion of those in the liver eventually degenerate. Evidently the worms in the vena cava are finally carried forward to the lungs. It is also possible that some of them work their way back through this vein to the kidneys, the spinal canal, and other tissues drained by the vein.

The pus formation associated with this parasite may be a factor in assisting its penetration through the capsule of the liver and later producing the fistulous tracts opening into the ureters. The possibility that the worms which are connected with the ureters by fistulous tracts reached this location by entering the kidneys, passing into the ureters, and penetrating the walls probably by way of the glands in these tubes, could not be demonstrated. Only the mature worm has been found in and projecting into the ureters. The movement of the mature worm through the fistulous tracts into the ureters was probably brought about by a lowering of the body temperature or other post-mortem changes.

In Porto Rico infection occurs during the entire year, but is heaviest during the summer months or wet season. At the local abattoir nearly all the livers which are condemned are rejected because of pathological lesions resulting from the development of the parasite. Records furnished by local sanitation officials for the last two years show that the number of livers condemned rarely falls below 10 per cent per month, but that during December and January, the months in which the migrating worms are most numerous, one-fourth to one-fifth of the livers are condemned. It is interesting to note that the beginning of the rainy season is followed five and six months later by an increase in the number and percentage of livers condemned at the local abattoir.

During 1928, 892 livers in a total of 6,323 were condemned. These figures do not represent the total number of animals or percentage infected with this parasite for several reasons. Often the liver lesions are localized in one lobe or small area; this part is rejected, and the liver is not included in the count.

### HOOKWORM OF SWINE

Further studies were made of the swine hookworm (*Necator suillus*). Locally the intestines of swine are used for sausage casings and are comparatively high in price. For this reason and because of the apparent low percentage of infection, a piece of the lower end of the ileum about 3 or 4 feet long was examined. If the worm was found, the entire intestine was obtained and examined.

At different times during the year 310 intestines were examined in this manner. Of this number only one lightly infested intestine was found. This, with the two reported in 1927, makes three infestations in a total of 478 intestines examined both systematically and as above-mentioned by the personnel of this station.

In the same districts from which many of these examined pigs were obtained the percentage of hookworm infestation in man is high, sometimes reaching 90 per cent. The same correlation exists in regard to ascarids. In Porto Rico the ascarids of swine are scarce, whereas they are common in man.

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